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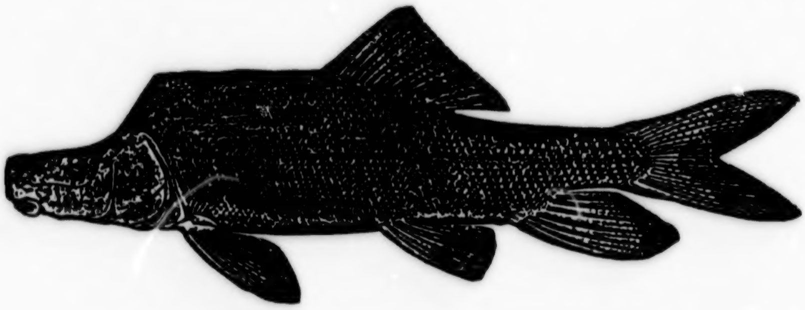
EXPERIMENTAL STOCKING OF ADULT RAZORBACK SUCKER IN THE UPPER COLORADO AND GUNNISON RIVERS



Final Report
June 1997

U. S. Fish and Wildlife Service

97-001853

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EXPERIMENTAL STOCKING OF ADULT RAZORBACK SUCKER IN THE UPPER COLORADO AND GUNNISON RIVERS

Recovery Program Project Number 50

Final Report

June 1997

Prepared for

Recovery Implementation Program
for Endangered Fishes in the
Upper Colorado River Basin

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This study was funded by the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. This Program is a joint effort of the U. S. Fish and Wildlife Service, U. S. Bureau of Reclamation, Western Area Power Administration, states of Colorado, Utah, and Wyoming, Upper Basin water users, environmental organizations, and the Colorado River Energy Distributors Association.

Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin, U. S. Fish and Wildlife Service, P. O. Box 25486, Denver Federal Center, Denver, Colorado 80225.

RECOVERY PROGRAM FOR
THE ENDANGERED FISHES
OF THE UPPER COLORADO

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Suggested citation:

Burdick, B. D., and R. B. Bonar. 1997. Experimental stocking of adult razorback sucker in the Upper Colorado and Gunnison rivers. Final Report prepared for the Recovery Implementation Program for Endangered Fishes in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 28 pp. + Appendices.

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List of Key Words: Upper Colorado River, Gunnison River, razorback sucker, radiotelemetry, stocking, dispersal and movement, survival, habitat use

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ACKNOWLEDGMENTS

The authors would like to thank the many individuals who participated in this study. Frank Pfeifer, U. S. Fish and Wildlife Service, was instrumental in negotiations with Mr. Etter for obtaining access to Etter Pond to collect adult razorback sucker. Frank along with Mike Baker, Dale Ryden, and Kathy Holley captured razorback sucker from Etter Pond; they also assisted in implanting radio transmitters in razorback sucker. Several others assisted in radiotracking: Caren Kram, Toby Mourning, Mike Montagne, and Greg Taylor.

The report was peer-reviewed by Tom Chart, Dr. Gordon Mueller, and Edmund Wick. Additional comments were provided by Dr. Tom Czapla.

EXECUTIVE SUMMARY

The purpose of this study was to evaluate the survival and performance of pond-reared, radiotagged adult razorback sucker following stocking in the Upper Colorado and Gunnison rivers. Specific objectives were to determine movement, distribution, dispersal patterns, and habitat use of fish stocked in the river. Twenty radio-implanted razorback sucker were stocked in historical habitat in the Upper Colorado River between Debeque and Rifle, Colorado, and 21 were stocked in the Gunnison River near Delta, Colorado, in April 1994. An additional four adult radiotagged razorback sucker were stocked in the Gunnison River in September 1995.

Stocked razorback sucker dispersed predominantly downstream following release in both rivers. In the Upper Colorado River the mean maximum displacement for the 20 fish was four times greater downstream than upstream (19.3 versus 4.8 miles). Ninety-six individual radio contacts were made periodically with 19 fish between 13 April 1994 and 11 August 1995. Radio contact ranged from 10 to 491 days. Five fish were contacted over a period of 400 days. Only nine radio contacts were made with three different fish during 1995. Eight fish exhibited both up- and downstream movement sometime during the contact period; only three fish exhibited greater upstream than downstream movement. Eleven fish exhibited only downstream movement. Three fish passed over the Government Highline Diversion and Price Stubb dams, and the Grand Valley Irrigation Diversion. One of these fish was later contacted in "Hotspot Pond" in the '15-Mile Reach'. At the end of the study, three fish moved back upstream near the point of release.

Other than the three fish that moved back upstream near the point of release in the Upper Colorado River, movement patterns were similar for razorback sucker stocked in the Gunnison River. A total of 195 individual radio contacts was made periodically with 23 fish between 12 April 1994 and 1 November 1995. Radio contact ranged from 29 to 532 days. Eleven fish were monitored for 113 to 146 days; only one fish was contacted over 150 days. Of the thirteen radio contacts during 1995, eight were from two fish released 13 September 1995. The five other radio contacts were from one fish stocked in 1994. The mean maximum displacement for the 23 fish was nine times greater downstream than upstream (14.3 versus 1.6 miles). Six fish exhibited both up- and downstream movement sometime during the contact period; only one fish exhibited greater upstream than downstream movement (13.0 vs 7.9 miles). Fourteen fish moved entirely downstream.

Post-stocking survival was less than anticipated in both river systems. At the termination of the study, in the Upper Colorado River, 3 fish were confirmed alive, 10 were missing, 2 were confirmed dead, and 5 were presumed dead. Confirmed mortality was 10%. Actual mortality was likely as high as 85% if missing and presumed dead fish were included. For fish stocked in the Gunnison River during 1994 and 1995, 3 fish were confirmed alive, 3 were missing, 2 were confirmed dead, and 17 were presumed dead. Confirmed mortality was 8%; actual mortality might have been as high as 88% if missing and presumed dead fish were included.

Mortality was not immediate but delayed following release for razorback sucker stocked both in the Upper Colorado and Gunnison rivers. The low number of radio contacts in 1995 suggests either radiotag failure or missing fish had moved outside the tracking search routes. Three habitat types used most frequently were main channel (47%), backwaters (23%), and eddy/pools (16%). Six control fish held for observation in ponds at Horsethief State Wildlife area all retained their radiotags. Four of these six control fish were later stocked in the Gunnison River; two of the control fish in the ponds died four months following handling and radiotag implantation which was attributed to a bacterial infection not associated to the surgical incision.

Stocking different sizes of razorback sucker and determining the optimum size to release should enhance post-stocking survival. Post-stocking survival might be enhanced if captive-reared fish are physically conditioned to flow prior to release. Conditioning captive-reared fish prior to stocking may physiologically and behaviorally prepare them to adapt faster and survive in riverine environments.

Recommendations include, 1) stocking fish as far upstream as possible due to the predominantly downstream dispersal of fish immediately following release. In the Gunnison River, fish should be stocked immediately downstream of Hartland Diversion Dam; the most feasible stocking location being Confluence Park boat launch. In the Upper Colorado River, fish could be stocked at Rifle (RM 240.7); 2) determining the optimum size of razorback sucker to stock to increase post-stocking survival by evaluating the survival and performance of different sizes of hatchery- and pond-reared razorback sucker to be stocked over the next 4 years in the Gunnison River; 3) stocking captive-reared razorback sucker in the spring, if the target fish have attained adequate size; 4) collecting food availability and density data (zooplankton densities) from potential reintroduction sites prior to stocking to determine if the habitat selected has suitable food resources for released fish; 5) determining if post-stocking survival might be enhanced if captive-reared fish are physically conditioned to flow prior to stocking; 6) determining if post-stocking behavioral stress can be reduced and survival increased if fish are allowed to slowly acclimate in a backwater before migrating to other riverine habitat; 7) stocking large numbers of various-sized razorback suckers, each marked with a unique, identification code or number, followed by intensive monitoring; and 8) recapturing stocked fish at 4 to 6-week intervals to assess body condition and health, growth, and assessing if any complications related to handling and tagging procedures occurred. Planned *in situ* river acclimation and conditioning studies with captive-reared, sub-adult razorback sucker might also prepare released fish to adapt better physiologically and behaviorally and provide insight into increasing post-stocking survival.

INTRODUCTION

General

The razorback sucker (*Xyrauchen texanus*) is one of several native fishes that were formerly common and widespread throughout warm-water reaches of the Colorado River Basin, primarily in the mainstem and large tributaries from Wyoming to Mexico. Razorback sucker numbers have declined appreciably since human alteration of the aquatic environment began in the basin near the turn of the century. The decline of the razorback sucker is attributed to changes in physical and biotic factors leading to very low recruitment because of high mortality during the larval and juvenile life stages. Although the causes are not known, recruitment failure may be due to deterioration of water quality and/or predation on eggs, larvae, and juvenile razorback suckers by nonnative fish. Reduction of high spring flows has altered the natural flooding cycle, and some investigators (McAda 1977; Tyus and Karp 1989; Osmundson and Kaeding 1991) attribute lack of recruitment, in part, to the reduced availability of inundated floodplains which historically provided spawning and feeding for adults and nursery habitat for young. Because of its precarious position, the U. S. Fish and Wildlife Service (FWS) listed the razorback sucker as an endangered species (effective 22 November 1991; Federal Register, Vol. 56, No. 2105, 23 October 1991) under authority of the Endangered Species Act of 1973 (FWS 1973).

Most investigators (e.g., Tyus et al. 1987; Osmundson and Kaeding 1989; Bestgen 1990) consider the razorback sucker to be much more rare than the endangered Colorado squawfish (*Ptychocheilus lucius*). In the Lower Colorado River, downstream of Glen Canyon Dam, a substantial population of razorback sucker persists in Lake Mohave but occurs only sporadically in riverine reaches (Marsh and Minckley 1989). In the Upper Colorado River Basin, the largest population of adult razorback sucker are found in the Green and Yampa rivers (Holden and Wick 1982; Lanigan and Tyus 1989). Total numbers of razorback sucker collected from the Upper Colorado River have declined dramatically since 1976. In the Upper Colorado River, only 25 adult razorback sucker were captured between 1980 and 1990 (Valdez et al. 1982) from riverine habitats; only seven adult fish have been captured since 1990 (Osmundson and Kaeding 1991; Burdick 1992; unpublished FWS data). The last adult razorback sucker in the Gunnison River was captured in 1981 (Holden et al. 1981). About 125 adult razorback sucker have been collected recently from lentic habitats in human-made gravel-pit ponds. The majority of these fish were captured in Etter Pond near Debeque, Colorado. These fish were determined from genetic analyses to be progeny from a few adults that gained access to Etter Pond during the high spring flows of 1983 and 1984 and subsequently became trapped in Etter Pond.

In the Gunnison River, wild razorback sucker are thought to be extirpated, and the present population in the Upper Colorado River is considered functionally extinct because so few fish remain to sustain stable populations in the riverine system. Remaining razorback sucker are composed exclusively of old adults in the Upper Colorado River. Neither spawning or recruitment have recently been documented. If limited recruitment is occurring, it is not sufficient to maintain populations in either river. Only a few juvenile razorback suckers positively identified have been collected from the Upper Colorado River Basin. Smith (1959) reported two juvenile razorback suckers from Glen Canyon during a preimpoundment study. Taba et al. (1965) collected eight juvenile razorback suckers from a Colorado River backwater downstream from Moab, Utah. In 1991, two juvenile razorback suckers were collected from the lower Green River (Gutermuth et al. 1994).

Background

So few adult riverine fish remain in the wild that it is unlikely that a population can be restored through natural reproduction. As a consequence, the Biology Committee has placed a high priority on reestablishing razorback sucker in the Upper Colorado and Gunnison rivers. Augmenting or restoring populations by stocking endangered fishes has been identified as one of the five elements for recovery of endangered fishes in the upper basin. A plan to evaluate stocking to augment or restore razorback sucker in the Upper Colorado River (Burdick 1992) was accepted by Recovery Program participants. That plan addressed the essential elements for an experimental stocking program to obtain fundamental information on the ecology of razorback sucker and to determine the feasibility of stocking as a recovery tool. The plan discussed the rationale and justification for the experimental stocking of adult fish, the genetic risks associated with experimental stocking, justification for selection of stocking areas, and the protocol and criteria to investigate the relation between size at stocking and survival and time of stocking. The plan also outlined research efforts and general procedures to monitor stocked fish and evaluate the stocking program.

Because too few riverine razorback sucker exist in the Upper Colorado River with which to conduct scientific studies or to sustain populations, stocking a few adult hatchery- or pond-reared fish would provide information to understand the ecology of wild razorback sucker in the river environment and evaluate the utility of stocking on a larger scale. Research with hatchery- or pond-reared fish may also provide a method to determine their habitat needs and biological interactions and thus eventually provide a mechanism to enhance their recovery. The factors affecting survival of razorback sucker in the riverine system must be determined before large-scale augmentation or re-introduction stocking can be expected to be successful. Experimental stocking of razorback sucker may discern whether factors such as competition, predation, imprinting, homing, survival, etc., are critical to their survival. More could be learned about distribution, movement, reproduction, recruitment, and growth following experimental stocking. This information would guide future stocking activities to augment existing populations or to restore extirpated ones.

Purpose and Objectives

The purpose of this study was to evaluate the survival and performance of pond-reared, radiotagged adult razorback sucker following stocking in the Upper Colorado and Gunnison rivers. This study was intended to answer specific research questions essential for recovery, and evaluate the utility of stocking sub-adult and adult-size, hatchery-produced fish in achieving recovery goals. Specific objectives were to:

1. determine movement, distribution, and dispersal patterns of razorback sucker released in the river,
2. determine survival and habitat use following stocking,
3. determine movement of radio-tagged fish prior to- and during the spawning period to evaluate potential spawning and to identify potential spawning areas,
4. determine the usefulness of pond-reared fish for augmenting or restoring wild populations,
5. determine the utility of using a very small number of fish to experimentally evaluate restoration or augmentation potential, and
6. provide recommendations for the number and size for stocking razorback sucker to augment or restore razorback sucker populations.

STUDY AREA

The study area was the Upper Colorado River from Rifle, Colorado, downstream to Westwater Wash (river mile [RM] 241.0-125.0) and the Gunnison River from Hartland Dam near Delta, Colorado, to the confluence with the Colorado River (RM 60.0-0.7). Both stream reaches are within critical habitat for razorback sucker.

METHODS

Adult razorback sucker[1] were captured from Etter Pond with trammel nets in early-April 1994. Adult razorback sucker were surgically implanted with 4.5-year radio transmitters. Advanced Telemetry Systems (ATS®) radio transmitters were equipped with an internal loop antennae, powered by a lithium battery, emitted a unique signal in the 40 Mhz frequency band, and weighed 27 g. The transmitter had a microprocessor chip to emit a signal for 12 h and be "asleep" or off for 12 h. This increased tag life expectancy to 4.5 years. Transmitter weight was no more than 2.8% of fish body weight. Following capture, all fish were held in a holding tank with 0.5% salt (by weight) solution. Fish were then anesthetized with MS-222, weighed (g), measured (total length [TL], mm), muscle-plugged for genetic analyses, and PIT-tagged. Implanted fish were injected with an antibiotic, Gentocin (0.5 ml/2 k body weight). Surgical procedures for implanting the radio transmitters followed that of Hart and Summerfelt (1975) and Tyus (1984). Following surgery, fish were held in a holding pen in Etter Pond for 24 h to recover. Fish were transported in a 225-gallon tank with 0.5% salt by vehicle to the stocking sites. Fish were stocked immediately into the river.

One razorback sucker was implanted with a non-functional radiotag and held in a pond at Horsethief State Wildlife Area (SWA) for observation. In March

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[1] Geneticists determined that razorback sucker from Etter Pond were 'pure' razorback sucker.

1995, five additional adult razorback sucker that had been previously captured from Etter Pond and held in ponds at Horsethief SWA plus the one razorback sucker with a non-functional tag were implanted with 4.5-year radio transmitters. These six fish were held for observation to determine possible effects from handling and surgery.

Radiotagged fish were tracked by boat April through August 1994 and March through October 1995. Fish were not tracked during the winter months of 1994 and 1995. An aluminum-jon boat with a 65-horsepower jet drive facilitated up- and downstream travel to monitor movements of radiotagged fish. An ATS® digital radio search-receiver with either an omni-directional whip or bi-directional loop antennae was used for all tracking trips. The location of each radiotagged fish was fixed by triangulation (Bovee 1986; Tyus 1988). Locations in the Colorado River were recorded in river miles upstream of the confluence with the Green River and locations in the Gunnison River were recorded upstream from the confluence with the Colorado River. Other pertinent data collected for each contact were general habitat type at the signal source and surface water temperature.

Radiotelemetry provided information on dispersal patterns, movement, and habitat use of adult razorback sucker following stocking. Radiotelemetered fish were grouped into five categories:

1. confirmed alive: at the time of last contact fish was actively moving upstream from the previous location.

2. confirmed mortality: the complete or partial body or carcass of the fish was recovered--identified by it's PIT tag and/or radio tag.

3. missing or disposition unknown: the fish may still be alive but contact with the radio signal was lost because the radio transmitter failed; the radio transmitter is still functional and in the fishes body cavity but the fish has moved outside the longitudinal search route; or the fish could be occupying a water depth that exceeds the detection capability of the radio receiver; radio transmitter could have been expelled or lost and the fish is still alive.

4. presumed dead: fish movement has ceased for a lengthy period of time; location of the radio signal and signal strength has remained static for a lengthy period of time (several weeks); numerous attempts to make the fish move by disturbing the water with boat motors, wading, or flogging the water with boat paddles has failed; radio signal has not moved upstream for sometime or since release.

Radio tracking data were examined to determine: 1) total number of radio contacts per fish, 2) period or total number of days that contact was maintained with a fish, 3) total number of river miles that a fish moved, from the most upstream contact to the most downstream contact (total longitudinal movement), 4) maximum up- and downstream distance moved following release, 5) maximum distance and direction that a fish moved from point of release to the point of last contact, and 6) time of day and date. Movement analysis did not include data if the radio signal remained in the same location and did not exhibit upstream movement for the remainder of the tracking period.

Habitat use was analyzed for fish that were confirmed alive or we confidently believed that were alive during radio contacts. Fish were confirmed alive if the radio signal was located upstream from the previous contact. Furthermore, habitat-use data were not used once a radio signal remained at the same location for the remainder of the study. Consequently, habitat-use data for fish that could not be verified alive or the radio signal did not move for several months were not used. These data may represent abnormal behavior of stressed or dying fish. For this reason, the total number of habitat observations were less than the radio contact observations in both rivers because we could not reliably determine if fish were alive or behaving normally during some radio contacts. Habitat classifications defined by the Interagency Standardized Monitoring Program were used to describe habitats occupied by radiotagged fish.

RESULTS AND DISCUSSION

Forty-one razorback sucker were implanted with radio transmitters 5 April 1994 and stocked prior to runoff (Appendix A; Tables A.1. and A.2.). Radiotagged adult razorback sucker were stocked in historical habitat at three sites between Rifle and Debeque (RM's 228.8, 220.9, and 211.1) and at three sites between Hartland Dam and the Roubideau Creek (RM's 59.4, 53.5, and 51.5). Fish were stocked into backwaters because it was believed that riverine habitats with no or low velocities would provide stocked fish the best opportunity to acclimate to the higher river velocities. Two sites, a backwater downstream of Parachute (RM 220.9) and an overflow side channel upstream of Debeque (RM 211.1) in the Upper Colorado River, were selected because adult razorback sucker had been captured there previously (Valdez et al. 1982; Personal communication, George Kidd).

Twenty razorback sucker (mean TL and weight: 502 mm and 1,194 g; range TL and weight: 451-534 mm and 966-1,498 g) were stocked in the Upper Colorado River 6 April. Seven fish each were stocked at RM's 228.8 and 220.9 and six were stocked at RM 211.1 (Figure 1). Twenty-one fish (mean TL and weight: 494 mm and 1,227 g; range TL and weight: 455-536 mm and 984-1,476 g) were stocked in the Gunnison River 7 April. Seven fish each were stocked at RM's 59.4, 53.5, and 51.5 (Figure 1). Another four radiotagged razorback sucker (mean TL and weight: 480 mm and 1,154 g; range TL and weight: 459-526 mm and 1,000-1,460 g) were stocked at RM 53.6 in the Gunnison River 13 September 1995. These four fish had been held in ponds at Horsethief SWA for observation--one since April 1994 and three since March 1995.

Movement, Dispersal Patterns, and Survivorship

Upper Colorado River

A total of 96 individual radio contacts was made periodically with 19 fish. Between 13 April 1994 and 11 August 1995, radio contact was made with fish on 38 different days. Radio contact ranged from 10 to 491 days (Table 1). Five fish

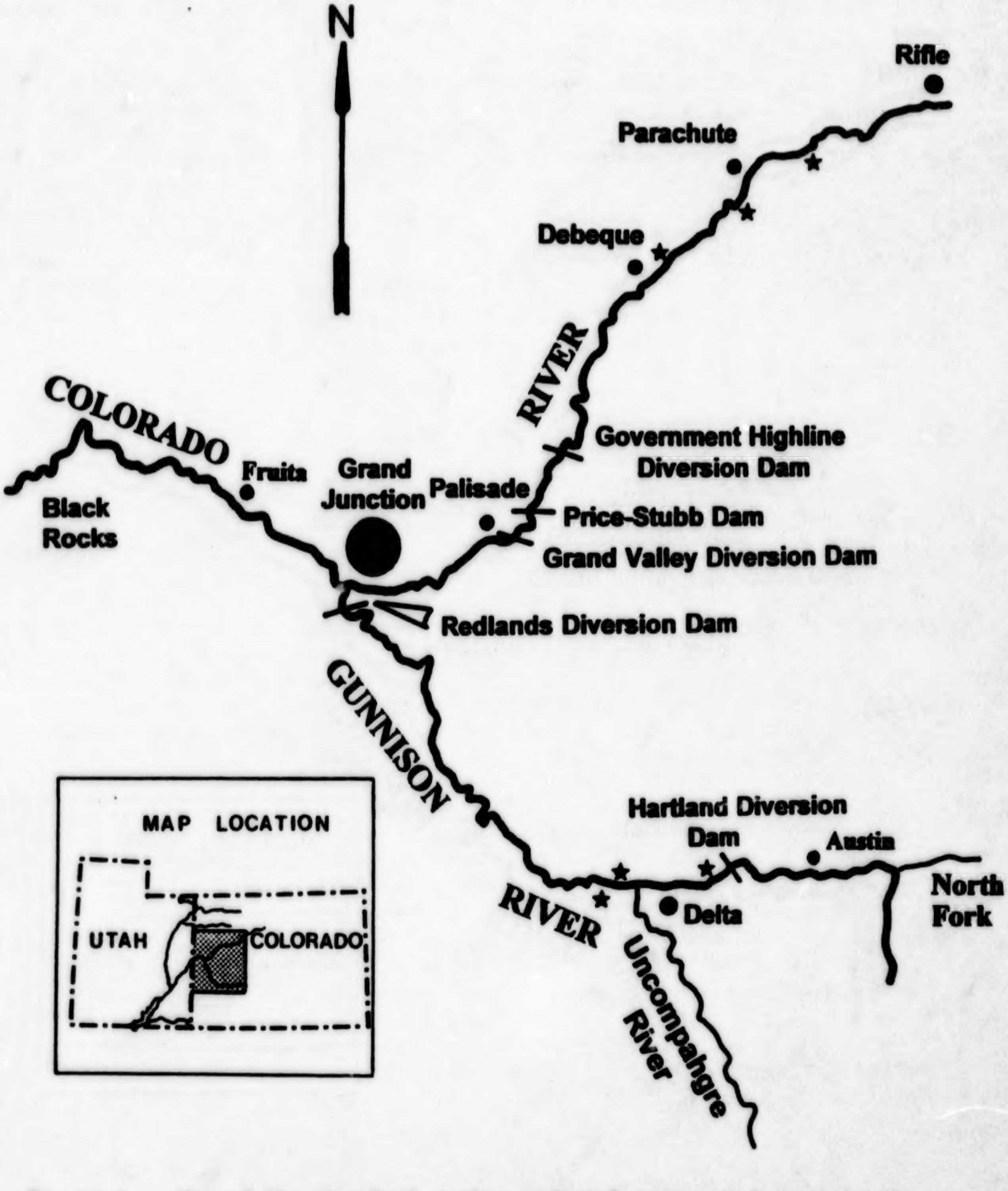

Figure 1. Map of the razorback sucker radiotelemetry study area in the Upper Colorado and Gunnison rivers. Sites where adult radiotagged razorback sucker were stocked in April 1994 are denoted by a closed star (✪). Upstream barriers to fish movement are denoted by a bar (/) perpendicular to the stream channel.

Table 1. Data for 20 adult razorback sucker implanted with radio transmitters and stocked in the Colorado River, 6 April 1994. Note: RM=river mile(s); radio frequencies were in the 40 Mhz band. See Figure 2 for movements of specific fish and Figure 3 for total maximum upstream and downstream displacement for each radiotagged fish.

Fish No. (Freq.)	Total Length (mm)/ Weight (g)	Release RM	Number of Contacts	Duration of Contacts (Days)	Total[a] Longitudinal Movement (RM)	Maximum[b] Displacement (RM)		Final[c] Displacement (RM)
						Upstrm	Dnstrm	
1(.010)	480/1,190	220.9	9	475	11.2	17.2	15.8	1.4(+)
2(.030)	486/1,218	220.9	6	85	17.3	0.0	17.3	17.3(-)
3(.050)	493/1,244	211.1	6	401	28.5	36.4	16.4	11.2(+)
4(.070)	494/1,210	211.1	2	85	15.3	11.6	15.3	3.7(-)
5(.090)	499/1,174	228.8	5	140	32.5	0.0	32.5	32.5(-)
6(.110)	534/1,308	228.8	9	141	13.6	0.0	13.6	13.6(-)[d]
7(.150)	477/1,036	220.9	0	0	--	--	--	--
8(.190)	532/1,416	228.8	1	10	0.0	0.0	0.0	0.0
9(.211)	483/1,068	220.9	6	140	27.1	0.0	27.1	27.1(-)
10(.241)	487/1,498	228.8	6	491	8.8	10.0	8.8	0.1(+)
11(.260)	489/1,252	211.1	7	124	40.5	0.3	40.8	40.5(-)
12(.300)	517/1,256	211.1	5	125	48.8	0.0	48.8	48.8(-)[d]
13(.320)	504/1,140	220.9	2	36	4.1	0.0	4.1	4.1(-)[d]
14(.340)	520/1,404	228.8	8	413	33.1	19.4	38.9	33.1(-)
15(.360)	532/1,394	211.1	4	111	15.4	0.0	15.4	15.4(-)[d]
16(.420)	451/ 966	228.8	8	491	9.2	0.2	9.4	9.2(-)
17(.541)	474/1,080	228.8	4	37	0.2	0.0	0.2	0.2(-)
18(.580)	526/1,428	220.9	2	50	27.1	0.8	27.1	26.3(-)
19(.620)	528/1,422	220.9	1	70	52.6	0.0	52.6	52.6(-)
20(.720)	526/1,432	211.1	5	50	1.5	0.0	1.5	1.5(-)
Totals	---	---	96	---	386.8	95.9	385.6	325.9(-) 12.7(+)
Mean	---	---	--	---	19.3	4.8	19.3	16.3(-) 0.6(+)

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[a] Total longitudinal movement is defined as the most upstream contact to the most downstream contact.

[b] Maximum displacement is defined as the maximum distance moved from release point following surgery either upstream or downstream during the entire monitoring period.

[c] Final displacement is defined as the distance from point of release following surgery to the last contact point: (+) represents upstream movement, (-) represents downstream movement.

[d] Tag eventually recovered. Dates tags were recovered: .110--08/25/94; .300--08/09/94; .320--05/12/94; .360--07/26/94

were contacted over 400 days. One fish (.150 Mhz) was never contacted following release. Only nine radio contacts were made with three different fish during 1995.

Following release, fish either remained at the stocking site or dispersed downstream. Throughout the study, fish collectively moved a total of 481.5 river miles, most of which was predominantly downstream (385.6 miles; Figure 2). The mean maximum displacement for the 20 fish was four times greater downstream than upstream (19.3 versus 4.8 miles; Figure 3). Eight fish exhibited both up- and downstream movement sometime during the contact period; only three fish (.010, .050, and .241 Mhz) exhibited greater upstream than downstream movement. Eleven fish exhibited only downstream movement. Of particular interest was the movement of one razorback sucker (.260 Mhz). This fish was released at RM 211.1 and passed over the Government Highline Diversion and Price Stubb dams, and the Grand Valley Irrigation Diversion. It was contacted on 24 and 27 June 1994 in "Hotspot Pond" at RM 174. It was last contacted downstream at RM 170.6 8 August 1994. Although two other fish (.300 and .620 Mhz) also passed over these three dams, it is uncertain whether they were alive at the time. Radiotag .300 Mhz was later recovered at RM 162.3, 9 August 1994 and the disposition of radiotag .620 Mhz is unknown since its last contact 15 June 1994 at RM 168.3. Fish .050 Mhz exhibited the greatest upstream movement. This fish moved 36.4 miles upstream and the last contact was 11.2 miles upstream from where it was stocked.

Fish .010, .050, and .241 Mhz were the only three fish that were determined to be alive at last contact. These three fish had all moved upstream from their former radio contact locations. Radio contact had been lost with these three fish for several weeks during runoff in 1995. These fish may have migrated to reaches upstream in the Upper Colorado River that were not searched during this time and returned downstream later following runoff, or, their radio signal was not detected by radio tracking crews during runoff. The movements of these three fish were unlike the 17 other stocked razorback sucker. All three of these fish initially moved downstream, eventually returned to their release sites, and then moved upstream from their release sites.

At the termination of the study, 3 fish were confirmed alive, 10 were missing, 2 were confirmed dead, and 5 were presumed dead. Four radiotags were recovered, the first on 12 May, the last on 25 August 1994. Mortality in 1994 did not appear to be immediate but delayed following stocking. The low number of radio contacts in 1995 suggests either radiotag failure or missing fish had moved outside the tracking search routes. In any event, post-stocking survival was low. Confirmed mortality was 10%. Actual mortality was likely as high as 85% if missing and presumed dead fish were included.

Gunnison River

A total of 195 individual radio contacts was made periodically with 23 of the 25 fish released. Between 12 April 1994 and 1 November 1995, radio contact was made with fish on 47 different days. Radio contact ranged from 29 to 532 days (Table 2). Eleven fish were contacted between 113 and 146 days; only one fish was contacted over 150 days (.683 Mhz). Two fish (.112 and .320 Mhz) were never contacted following release. Of the thirteen radio contacts during 1995,

Table 2. Data for 25 adult razorback sucker implanted with radio transmitters and stocked in the Gunnison River, 7 April 1994 and 13 September 1995. Note: RM=river mile(s); radio frequencies were in the 40 Mhz band. See Figures 4 and 5 for movements of specific fish and Figure 6 for total maximum upstream and downstream displacement for each radiotagged fish.

Fish No. (Freq.)	Total Length (mm)/ Weight (g)	Release RM	Number of Contacts	Duration of Contacts (Days)	Total[a] Longitudinal Movement (RM)	Maximum[b] Displacement (RM) Upstrm	Maximum[b] Displacement (RM) Dnstrm	Final[c] Displacement (RM)
1(.112)	522/1,450	53.6	0	0	--	--	--	--[d]
2(.130)	472/1,128	51.5	6	125	14.7	0.2	14.9	14.7(-)
3(.170)	474/1,092	59.4	10	117	0.0	0.0	0.0	0.0[e]
4(.320)	475/1,000	53.6	0	0	--	--	--	--[d]
5(.380)	463/1,132	51.5	4	29	7.9	0.0	7.8	7.9(-)[e]
6(.390)	504/1,300	53.6	5	49	2.1	0.5	2.6	2.1(-)[d]
7(.400)	459/1,034	51.5	13	94	0.0	0.0	0.0	0.0[e]
8(.410)	526/1,350	53.6	5	43	10.8	3.7	11.0	7.3(-)[d]
9(.440)	524/1,310	59.4	10	117	1.3	0.0	1.3	1.3(-)[e]
10(.460)	464/ 984	51.5	8	113	18.4	0.0	18.4	18.4(-)[e]
11(.470)	530/1,404	59.4	3	30	23.3	0.0	23.3	23.3(-)[e]
12(.480)	527/1,456	51.5	6	146	59.3	0.0	59.3	59.3(-)
13(.502)	536/1,448	51.5	12	133	10.7	13.0	7.9	5.1(+)
14(.520)	475/1,092	59.4	11	138	19.5	0.0	19.5	19.5(-)
15(.560)	455/1,036	53.5	7	139	29.9	0.0	29.9	29.9(-)[e]
16(.600)	499/1,284	59.4	7	47	16.6	0.0	16.6	16.6(-)
17(.640)	473/1,218	59.4	4	30	19.5	0.0	19.5	19.5(-)[e]
18(.660)	526/1,282	53.5	14	133	2.0	0.0	2.0	2.0(-)
19(.680)	462/1,066	51.5	15	532	16.5	22.6	26.3	3.7(-)
20(.700)	512/1,438	53.5	10	96	10.6	0.0	10.6	10.6(-)
21(.740)	480/1,020	53.5	7	70	0.0	0.0	0.0	0.0[e]
22(.760)	466/1,078	51.5	2	55	48.4	0.0	48.4	48.4(-)
23(.780)	482/1,156	53.5	15	55	0.7	0.0	0.7	0.7(-)
24(.800)	526/1,476	53.5	10	139	22.1	0.0	22.1	22.1(-)
25(.820)	467/1,142	53.5	11	138	14.9	0.1	14.9	14.9(-)
Totals	---	---	195	---	349.2	40.3	357.0	322.2(-) 5.1(+)
Mean	---	---	--	---	14.0	1.6	14.3	12.9(-) 0.2(+)

---

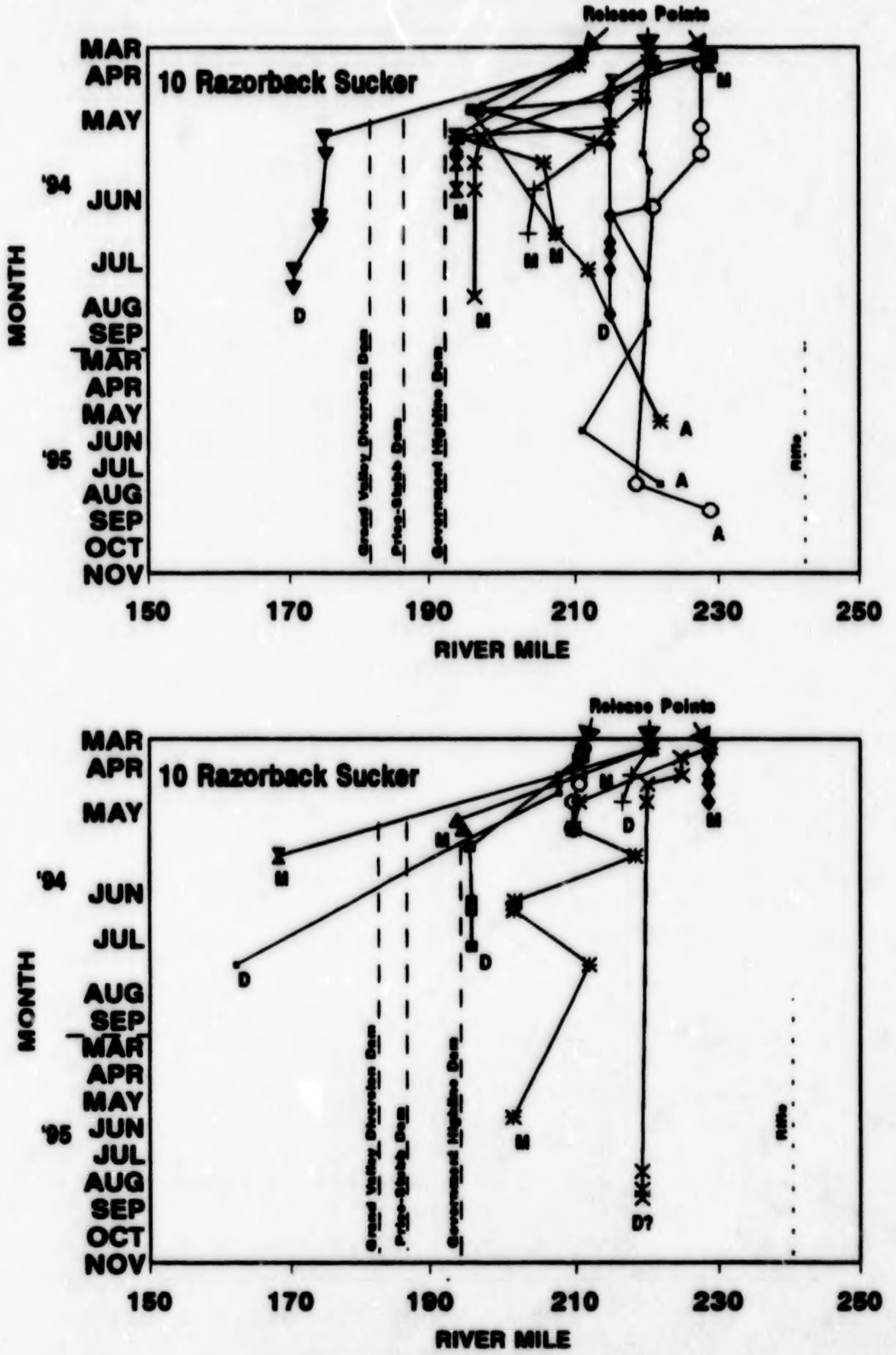
[a] Total longitudinal movement is defined as the most upstream contact to the most downstream contact.

[b] Maximum displacement is defined as the maximum distance moved from release point following surgery either upstream or downstream during the entire monitoring period.

[c] Final displacement is defined as the distance from point of release following surgery to the last contact point: (+) represents upstream movement, (-) represents downstream movement.

[d] Stocked 13 September 1995.

[e] Tag eventually recovered. Dates tags were recovered:
.170--08/01/94; .380--05/05/94; .400--07/22/94; .440--08/01/94;
.460--07/28/94; .470--05/06/94; .560--08/23/94; .640--05/06/95;
.740--06/15/94



Upper Colorado River
1994 & 1995 Razorback Sucker Radiotelemetry

Figure 2. Movement of 20 radiotagged adult razorback sucker in the Upper Colorado River, April-August 1994 and March-November 1995. Fish were released at three different backwater locations between Debeque and Rifle, Colorado, 5 April 1994. There were 38 contact dates and 96 individual radio contacts for these 20 fish. Note: A=fish alive, D=fish dead, M=fish missing.

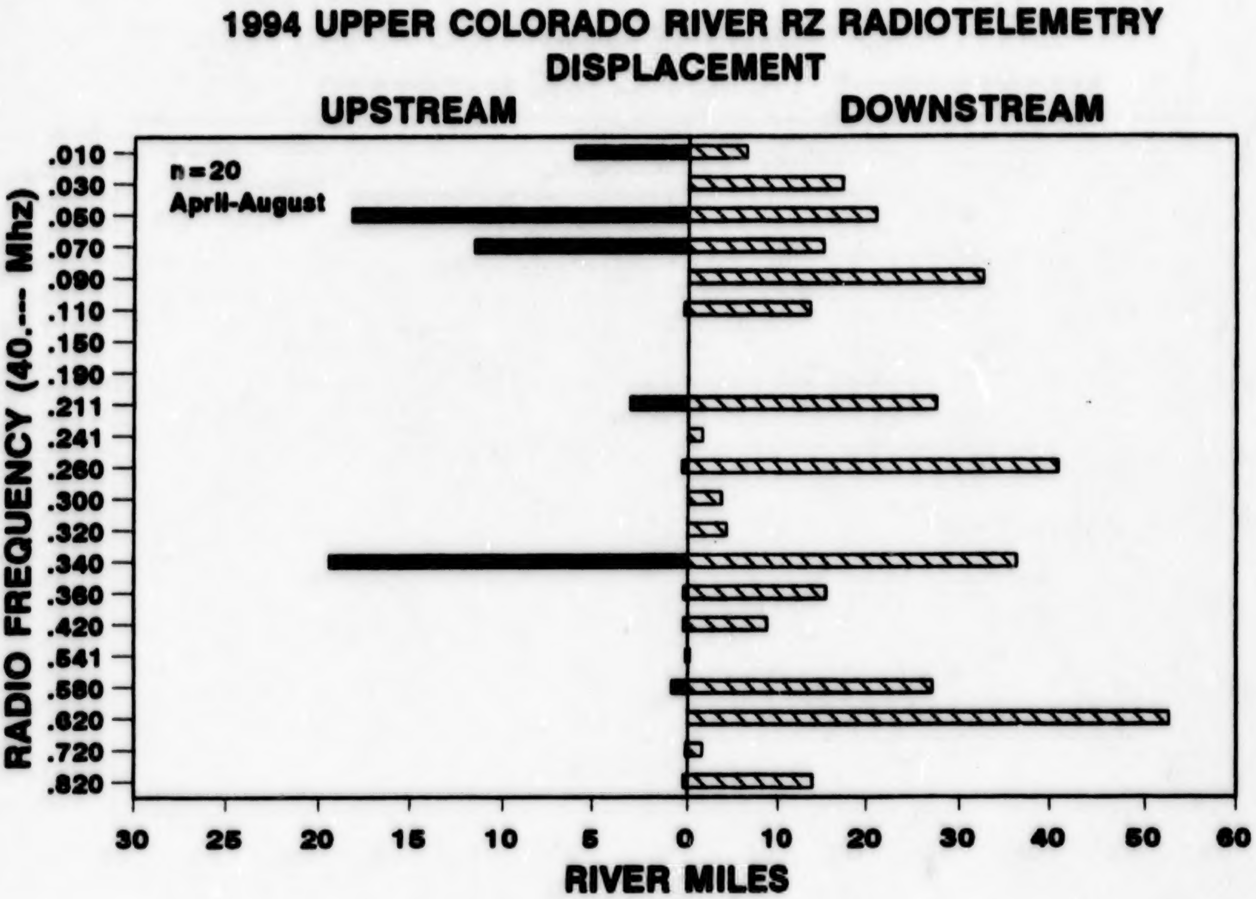


Figure 3. Total maximum upstream and downstream displacement (from release point: '0' on the X-axis) for 20 radiotagged adult razorback sucker monitored between March and September 1994 and March and November 1995 in the Upper Colorado River, Colorado. Note: the upstream scale is one-half that of the downstream scale.

eight of these were from two fish released 13 September 1995. The five other radio contacts were from one fish (.683 Mhz) stocked in 1994.

As with razorback sucker released in the Upper Colorado River, fish either remained at the stocking site or dispersed downstream. Throughout the study, fish collectively moved a total of 397.3 river miles, most of which was predominantly downstream (357 miles; Figures 4 and 5). The mean maximum displacement for the 23 fish was nine times greater downstream than upstream (14.3 versus 1.6 miles; Figure 6). Six fish exhibited both up- and downstream movement sometime during the contact period; only one fish (.502 Mhz) exhibited greater upstream than downstream movement (13.0 versus 7.9 miles). Fourteen fish exhibited only downstream movement. Fish .683 Mhz exhibited the greatest upstream movement. This fish moved 22.6 miles upstream and the last contact was 3.7 miles downstream from where it was stocked. Two razorback sucker (.480 and .760 Mhz) passed over the Redlands Diversion Dam. Fish .760 Mhz passed over the

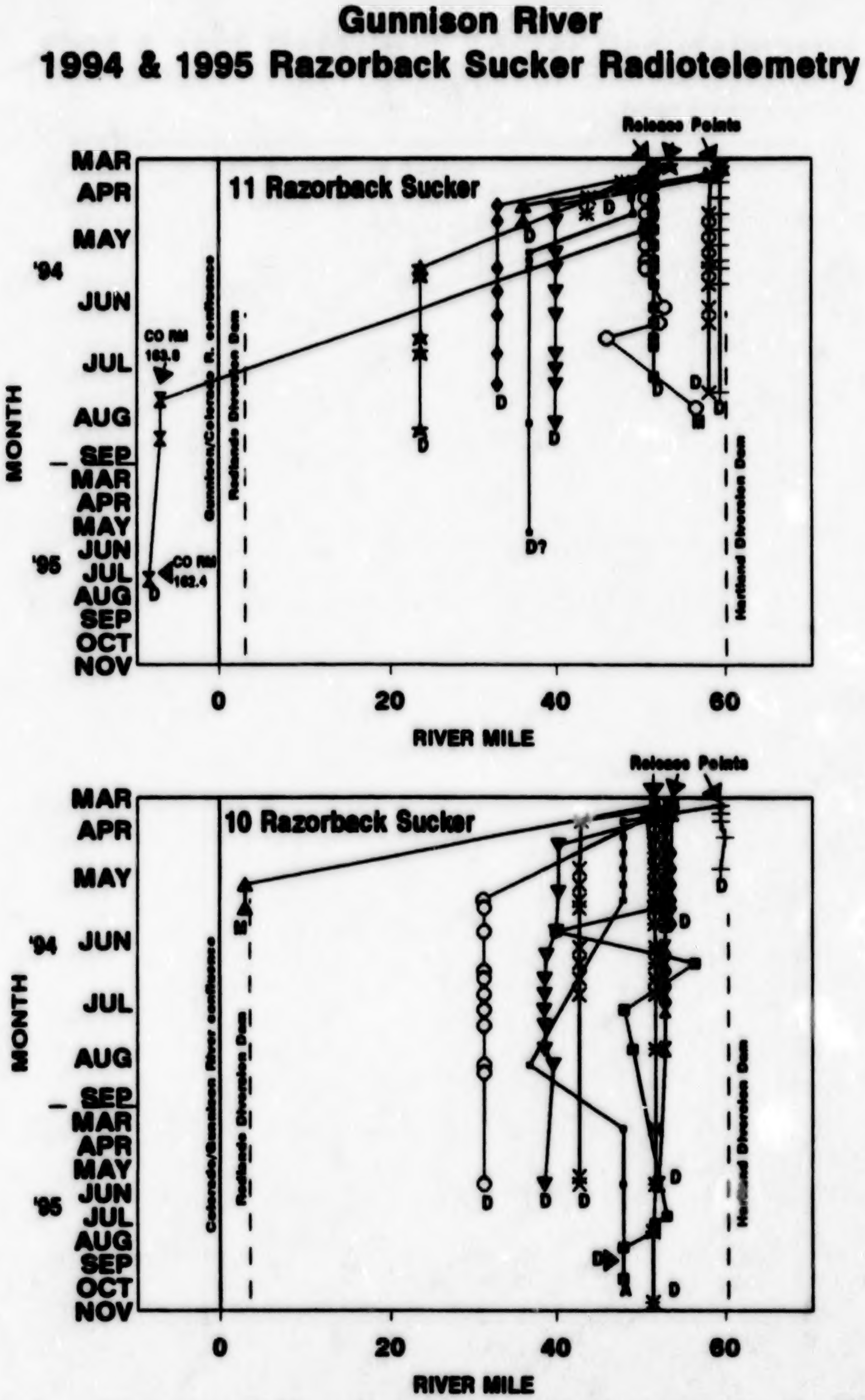


Figure 4. Movement of 21 radiotagged razorback sucker in the Gunnison River, April-August 1994 and March-November 1995. Fish were released at three different backwater locations between Escalante State Wildlife Area and Hartland Diversion Dam, 6, 7, and 20 April 1994. There were 47 contact dates and 185 individual radio contacts for these 21 fish. Note: A=fish alive, D=fish dead, M=missing fish.

dam sometime between 7 April and 17 May 1994. It was last contacted in the Redlands Diversion Dam plunge pool 31 May 1994. Fish .480 Mhz passed over the dam sometime between 10 May and 9 August 1994. The radio signal of fish .480 Mhz was contacted on 9 August and 30 August 1994 at RM 163.2 in the Colorado River. It was last contacted 14 July 1995 at RM 162.4 in the Colorado River. The predominant downstream movement of these two fish leaves uncertainty how long they were alive following release, if they were alive when passing over the dam, or if only the radiotag passed over the dam. Because the disposition of these two fish during the last radio contact was uncertain and no upstream movement was observed, they are presumed dead.

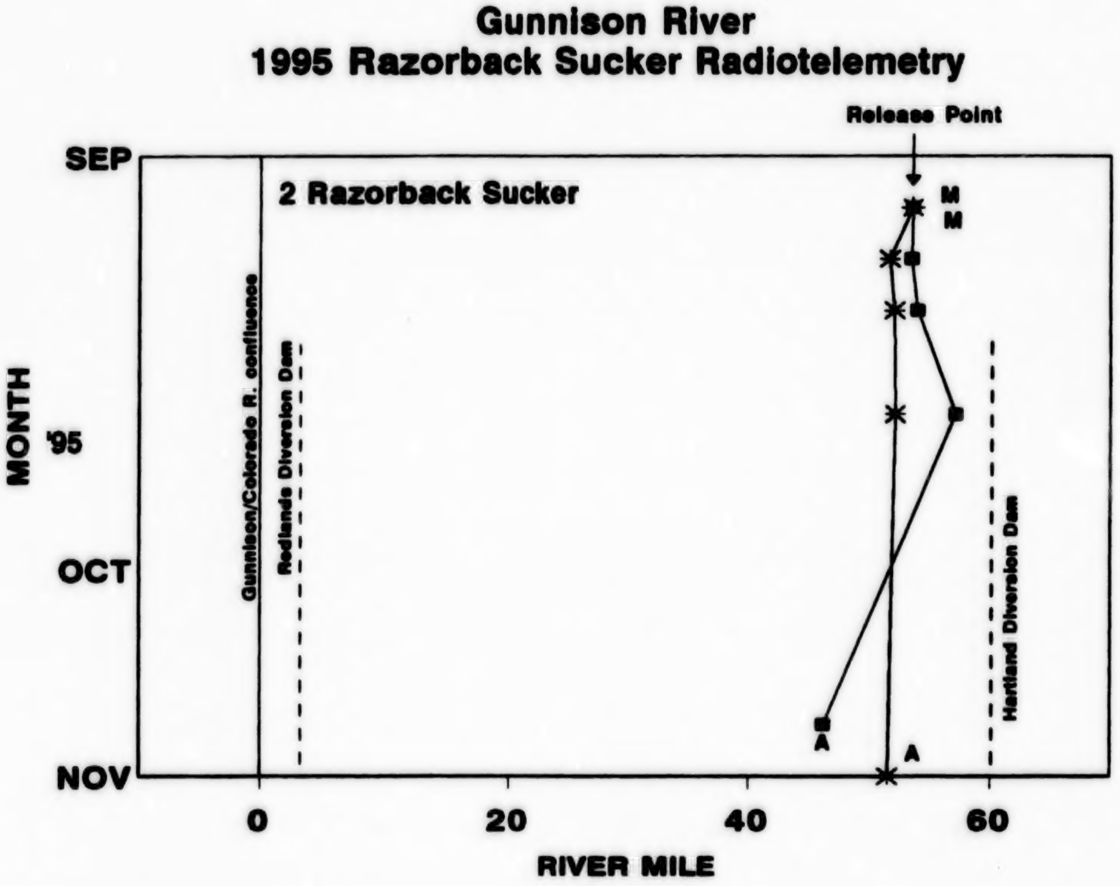


Figure 5. Movement of two radiotagged razorback sucker in the Gunnison River, September-November 1995. Fish were released at a backwater, river mile 53.6, immediately upstream of Escalante State Wildlife Area, 13 September 1995. Note: A=fish alive, D=dead, M=missing.

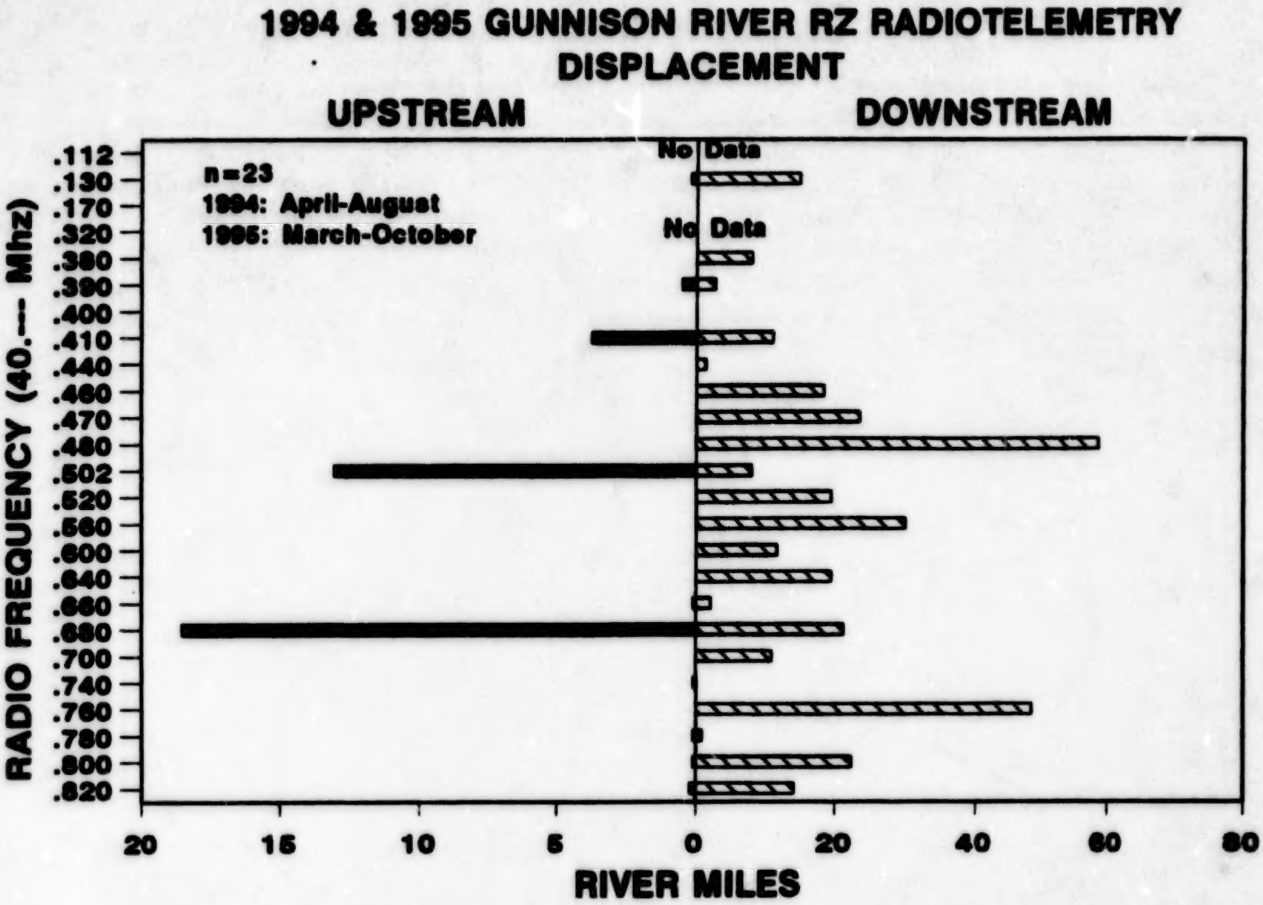


Figure 6. Total maximum upstream and downstream displacement (from release point: '0' on the X-axis) for 25 radiotagged adult razorback sucker monitored between March and September 1994 and March and September 1995 in the Gunnison River, Colorado. Note: the upstream scale is one-fourth that of the downstream scale.

At the end of the study, 3 fish were confirmed alive, 3 were missing, 2 were confirmed dead, and 17 were presumed dead. Nine radiotags were recovered, the first on 5 May, the last on 23 August 1994. As with fish stocked in the Upper Colorado River, mortality of razorback sucker stocked in the Gunnison River in 1994 did not appear to be immediate but delayed following release. Post-stocking survival was low for fish stocked in the Gunnison River during 1994 and 1995: confirmed mortality was 8%; actual mortality might have been as high as 88% if missing and presumed dead fish were included.

San Juan River

One concern when stocking fish in large rivers is the vast downstream displacement that usually follows release. Movement data from pond-reared razorback sucker released in the Upper Colorado and Gunnison rivers indicates that the majority of downstream displacement occurs within the first few weeks following stocking. Radiotagged razorback sucker exhibited similar movement patterns and behavior following stocking at different sites in the San Juan River (Ryden and Pfeifer 1995; 1996). The mean downstream displacement for radiotagged razorback stocked in the spring in the San Juan River was 10.5 miles, compared to 19.3 miles for razorback sucker stocked in the Upper Colorado River and 14.3 miles for fish stocked in the Gunnison River. The mean downstream displacement for radiotagged razorback sucker stocked during the fall of 1994 (54.0 miles) and 1995 (58.2 miles) in the San Juan River was greater than those stocked in the spring (Ryden and Pfeifer 1995; 1996).

Thirty-four, adult, pond-reared razorback sucker, implanted with both internal and external sonic tags, were stocked in the San Juan River inflow area of Lake Powell in the fall of 1995 and their movements monitored (Karp and Mueller 1996). During the 11 months that contact was maintained, several of these fish exhibited fairly long up- and downstream movements following stocking; others made only one-way movements. Of the fish contacted, all appeared to remain in the inflow area of Lake Powell in the Lower San Juan River following release; none of the tagged razorback sucker made obvious downstream movements into Lake Powell. One fish, after moving downstream 3 miles then moved upstream 43 miles; another fish initially moved downstream 19 miles and then returned upstream 29 miles. Both of the upstream movements occurred during spring, and these researchers suggested that not only were the fish seeking certain types of habitats but that movements may be possibly related to spawning behavior.

The initial downstream movement of stocked fish may be in response to these fish searching for adequate food resources and riverine habitat (Personal communication, Edmund Wick) or fright and traumatic, behavioral stress related to handling, stocking, and exposure to a new environment (Personal communication, Gordon Mueller).

Once passage to upper reaches is more generally available, another alternative would be to stock in lower reaches like lake inflows or extensive connected pond areas in lower stream reaches. U. S. Geological Survey (USGS) researchers plan to further investigate the utility of stocking captive-reared razorback sucker in lower stream reaches near inflow areas (San Juan River arm of Lake Powell) where food availability and productivity is high. Higher water temperatures and greater food availability may make lower stream reaches better for reintroducing captive-reared razorback sucker until more off-channel and floodplain habitat in upper stream reaches are made accessible (Personal communication, Edmund Wick). Stocked razorback sucker can remain in lower velocity, food rich, and warmer feeding areas during reintroduction and move upstream to better spawning habitat when they feel the urge to explore and expand their range. They can learn the river from downstream to upstream instead of being forced downstream by high velocity, low food density, and competition with other river suckers.

Reducing fright and traumatic stress related to stocking may be an important factor in the ultimate survival of razorback sucker. USGS researchers will monitor the response and survival of captive-reared razorback sucker stocked in new riverine environments. The test will determine if post-stocking behavioral stress can be reduced and survival increased if fish are allowed to slowly acclimate in a backwater before migrating to other riverine habitats.

Plans are to stock razorback sucker in a backwater or inflow area (San Juan River arm of Lake Powell) in 1997 and 1998. One group of razorback sucker will be released and allowed to escape the backwater, migrate into the main channel voluntarily following stocking, and roam free. Another group of razorback sucker will be stocked and held in a backwater temporarily (3 to 6 days) that has been blocked off with nets to prevent fish from migrating to the river. Therefore, stocked fish will be preconditioned by allowing them to slowly acclimate to the backwater. In time, block-off nets will be removed and fish will ultimately be allowed to migrate from the backwater into the river. Recapturing stocked fish or monitoring their movement with telemetry will be critical to evaluating each group's survival. Additional testing of this hypothesis will be conducted with pond-reared razorback sucker stocked in Lake Mohave (1997 and 1998) and in the lower Green River (1998) in Canyonlands National Park (Personal communication, Gordon Mueller).

Reasons for Low Survival

We can speculate why survival was low for pond-reared adult razorback sucker stocked in the Upper Colorado and Gunnison rivers. Captive-reared fish that are stocked into the river may not be able to cope with the riverine environment unless they are physically conditioned prior to release (Sanger 1993). Pond-reared razorback sucker that had not been accustomed to flow may therefore have not been physiologically or behaviorally adapted for riverine life. Radio-implanted fish were all stocked in no or low-velocity riverine habitats, similar to the pond environment where they had spent their entire life, to allow gradual conditioning to various river currents and velocities. Fish were stocked in early April and should have had ample time to adjust to the increased flow velocities associated with runoff. Inspection at the time of radio-implantation revealed vast amounts of fat in their body cavities, indicating fish were in good condition in spring 1994 prior to being stocked in the river environment. One hypothesis is that food items utilized and possibly preferred by razorback sucker in Etter Pond were not available in the river at the time of stocking or that fish had developed a specific "search image" for preferred food items while in the pond and were not physiologically or behaviorally capable of utilizing riverine organisms, even though food may have been available.

The relation of food at the time and location of stocking is also critical to survival. Post-stocking survival is often related to the Match or Mismatch Principle where environmental conditions such as water temperature as well as the quality and quantity of food organisms must match the needs of the fish at time of stocking in river backwaters to realize high survival (Hjort 1914; 1926). In other words, food resources must "match" or be available at the time of or following stocking to increase survival of stocked fish. This is especially critical for larval razorback sucker. However, in both the Upper Colorado and Gunnison River systems, stocked razorback sucker had ample time to utilize food resources in the river since mortality was delayed and occurred over several months following stocking. If stocked fish did not utilize riverine food resources, one reason mortality was delayed is that stocked fish may have had adequate fat reserves to initially sustain them, but were not capable of converting to or learning to utilize natural food items in the river and, consequently, slowly starved.

Another reason for the presumed low survival is that radiotagged razorback sucker expelled or lost the radiotag following stocking in the Upper Colorado and Gunnison rivers. The fish could have survived or died following loss of the tag. Some razorback suckers implanted with AVM® internal radiotags and held in ponds at Wahweap, Utah, lost their tags within one week. Researchers believed that, following surgery, fish rubbed their abdominal region against the concrete kettle and loosened the sutures resulting in the tag falling out. Twice in 1994 and once in 1995, when fish were implanted with radiotags, tag loss was about 50% approximately within one week. In 1996, tag lost was about 30% (Personal communication, Dale Ryden). Tag loss was essentially zero after one week. Expulsion may explain the constant downstream movement of the radiotag in this study and it ultimately coming to rest and being lodged in the same location. Although unlikely, tag failure of a number of radiotags or poor reception capabilities of the radio receiver may be other reasons for low detection and thus assumption of poor survival.

Mortality associated with netting, handling, and radiotag surgery was unlikely. One razorback sucker was implanted with a non-functional radio tag April 1994 and held in ponds at Horsethief SWA for observation until March 1995. At that time, this fish along with five other sub-adult and adult razorback sucker were implanted with radiotags and held in ponds at Horsethief for further observation. Two of these six razorback sucker died 27 July 1995. Death was attributed to a bacterial infection (Personal communication, Mike Baker). The infection was not associated with the radiotag surgical incision because other razorback sucker broodstock held in the same pond also were infected at the same time. Therefore, four radiotagged razorback sucker survived in the pond, one for about 18 months following surgery and three others for about 6 months following surgery. None of these fish lost their radiotags while being held in the ponds. These same four surviving fish were stocked in the Gunnison River September 1995.

The fate of razorback sucker stocked in 1994 and 1995 in the Upper Colorado and Gunnison rivers may never be known or at least not for several years. However, razorback sucker are long-lived and fish that were missing or might have lost their radiotags could have survived and might be recaptured in future years. If these fish are recaptured, they could be identified by PIT tags.

Pond-reared razorback sucker stocked into the San Juan River have survived for almost three years and appeared in good condition when captured (Ryden and Pfeifer 1996). Furthermore, the recapture rates for larger stocked razorback sucker (mean and range [TL mm]: 364; 204-482) were greater than smaller sizes stocked (mean and range [TL]: 190; 100-374). During sampling of the San Juan River over a period of 31 months following the stocking of these fish, only three of the 478 (0.6%) smaller-sized razorback sucker were recaptured whereas 46 of the 461 (10%) larger-sized razorback sucker were recaptured (Personal communication, Dale Ryden). Neither of these two groups of razorback sucker stocked in the San Juan River in 1994 and 1995 had been conditioned prior to release. Therefore, stocking pond-reared fish without any prior conditioning does not guarantee failure. For razorback sucker stocked in the Upper Colorado and Gunnison rivers, some of the mortality might be attributed to lack of conditioning, but many other factors could be involved.

Preliminary flow-training trials conducted at Utah State University indicate that the red muscle cells, which are essential for sustained swimming in current, increased both in size and number when bonytail (*Gila elegans*) were intermittently subjected to flow (1 hour of flow/3 hours of no flow) and exercised in circular tanks (Crowl et al. 1995). In the riverine environment, fish not physically trained or exercised to flow may be at a disadvantage because they remain in low velocity areas and may not physically maintain themselves in high velocity for short periods where densities of preferred food might be higher (Personal communication, Todd Crowl). Pond-reared razorback sucker stocked in the Upper Colorado and Gunnison rivers may have not been capable of switching to available food items in the river soon enough because they were not able to move to areas of abundant food resources and, consequently, slowly starved. Therefore, critical for survival might be the ability for stocked razorback sucker to learn to acclimate, move to, and maintain themselves in flowing water habitats to utilize abundant food items. Physical conditioning to flow may be important and subsequently critical for fish to utilize available food items in the environment that they are stocked, and their ultimate ability to survive.

Modde and Meyer (1991) believed that the high mortality of captive-reared bonytail stocked in the Upper Green River, Utah, in 1988 and 1989 (Chart and Cranney 1990) was the result of the failure of individuals to adapt to natural conditions rather than the inability of the species to survive in a natural environment. Chart and Cranney (1990) strongly advised against release of any hatchery-reared adult bonytail into a riverine environment, without a lengthy period of conditioning (e.g., flow conditioning).

Crowl et al. (1995) hypothesized that bonytail should be raised in flow for as long as possible prior to stocking and simulating a natural environment would assist bonytail to adapt both physiologically and behaviorally to any reintroduction site.

The Colorado Division of Wildlife recommends stocking fingerling (3 to 4-inch), hatchery-reared rainbow trout rather than younger (2-inch and smaller) or older, larger trout because post-stocking survival is greater (Nehring 1990). Older salmonid piscivores reared in static water may require more time to adapt both physiologically and behaviorally to lotic water conditions than younger fish. Learning and physical conditioning, similar to imprinting, may occur only early in life, and once past a certain age, cannot be "triggered" or initiated. Older, captive-reared fish, although they may have adequate fat reserves, may take too long to learn to convert to natural feed or simply may not utilize natural feed following stocking. However, several factors such as time of year stocked, type of habitat stocked, acclimation period, predators, handling and transport stress, and genetics (wild versus domestic; Nehring 1990) also influence post-stocking survival.

Habitat Use

Upper Colorado River

Fifty-seven habitat observations were obtained from 12 different fish. Fish used seven different habitat types: main channel, backwaters, eddy/pools, side channels, embayments, pools, and gravel-pit ponds (Figure 7). Habitat-use observations were combined for all fish and for the 5- and 8-month period in 1994 (April-August) and 1995 (March-October), respectively. The three habitats selected most by radiotagged razorback sucker were main channel (59.6%), backwater (17.5%), and eddy/pool (10.5%). Fish used side channels, pools, and gravel-pit ponds each 3.5% of the time. Eleven of the 12 fish used the main channel habitat, six used backwaters, four used eddy/pools, and two each used side channel and pools. Habitat used by each of these 12 fish is provided in Appendix; Table B.1.

Because the movement of the three fish (.010, .050, and .241 Mhz) believed to be alive at the termination of the study was different than other fish stocked, the habitat used by the three fish was contrasted to the other razorback sucker. The three fish believed to be alive at the termination of the study used main channel habitats less than the other fish (40% versus 68%) but used eddy/pools more (35% versus 0%; Table 3).

Table 3. Comparison of habitat use by three razorback sucker in the Upper Colorado River that were confirmed alive at the termination of the study versus nine other razorback sucker stocked in the Upper Colorado River.

	Three Razorback Sucker (0.10, .050, .241 Mhz)		Nine Razorback Sucker (.070, .090, .260, .360, .420 .541, .580, .620, 720 Mhz)	
Habitat Type	No. of Observations	Percentage	No. of Observations	Percentage
Main Channel	8	40	26	68
Eddy/Pool	7	35	0	0
Side Channel	1	5	1	3
Embayment	0	0	1	3
Pool	2	10	0	0
Backwater	2	10	8	21
Gravel Pit	0	0	2	5

Gunnison River

One-hundred nine habitat observations were obtained from 15 different fish. Three of the nine habitat types used more frequently were main channel (40.4%), backwaters (25.7%), and eddy/pools (19.3%). Other habitats used less frequently were side channels (5.5%), tributary streams (3.7%), embayments and shorelines (each 1.8%), and pools and isolated pools (each 0.9%; Figure 8).

Thirteen of the 15 razorback sucker used the main channel habitat, 10 used backwaters, 9 used eddy/pools, 6 used side channels, and 2 fish occupied Roubideau Creek, a tributary stream. Habitat used by each of these 15 fish is provided in Appendix; Table B.2.

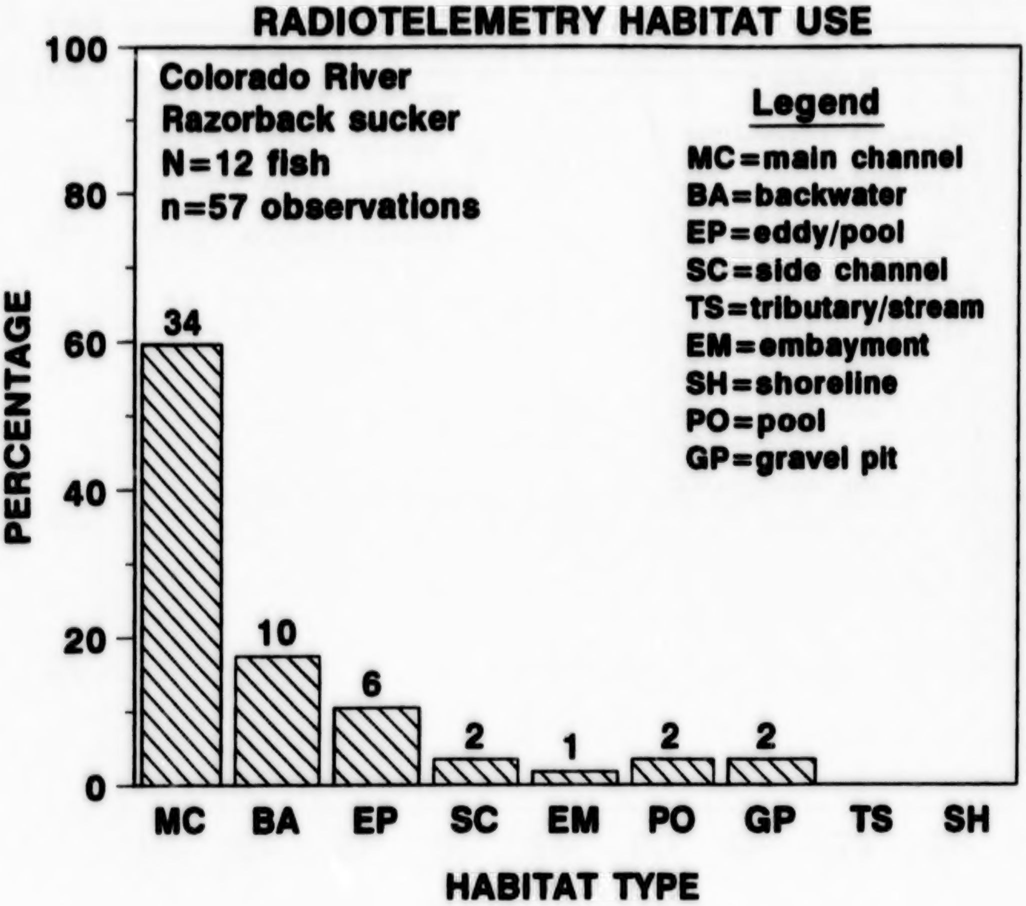


Figure 7. Cumulative frequency of habitat use for 12 radiotagged razorback sucker in the Upper Colorado River, April-August 1994 and March-October 1995. The value immediately above the bars indicates the cumulative number of observations per habitat type for all 12 fish. Refer to Appendix; Table B.1. for frequency of habitat used per fish.

Habitats used by these fish did not necessarily indicate habitat preference. More meaningful data would be to determine habitat preferred by razorback sucker. To determine if razorback sucker prefer particular habitat types, usage would have to be compared with habitat availability. However, habitat availability was not determined or calculated in the immediate vicinity when a fish was contacted. In this study, the priority was to determine 1) general fish movement and dispersal 2) survivorship following stocking, and 3) general habitat use.

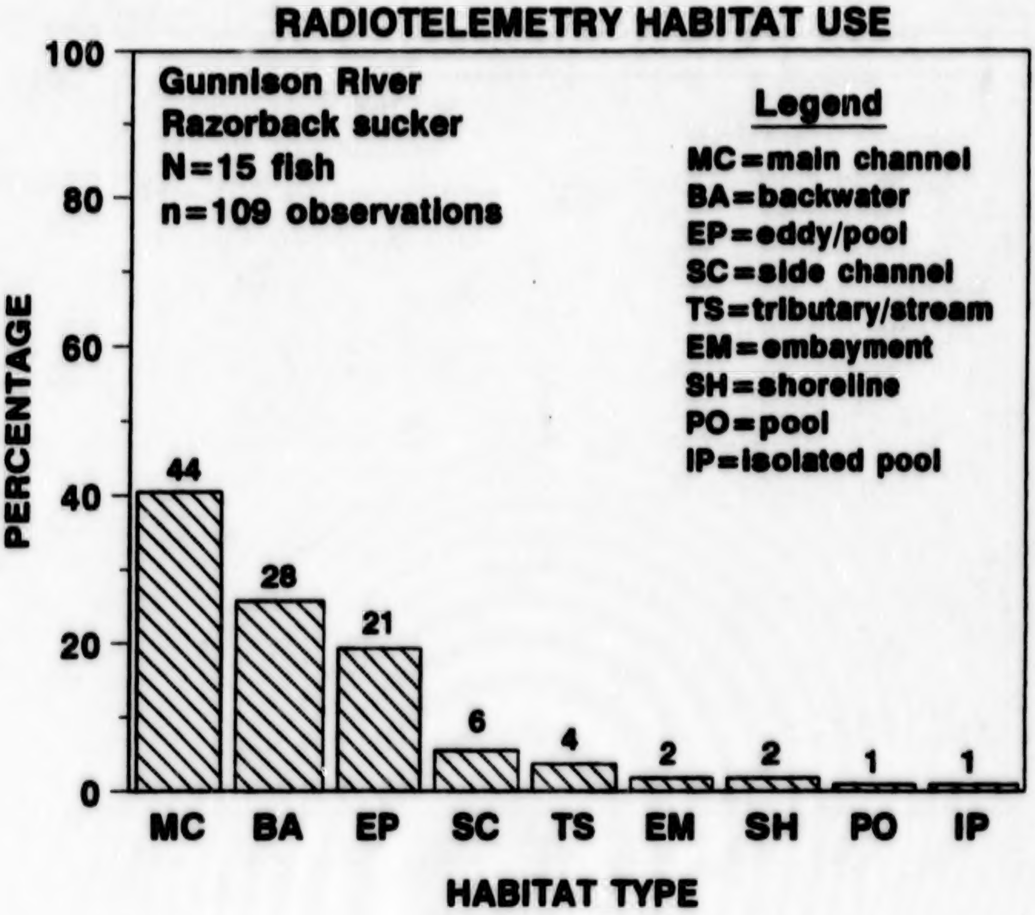


Figure 8. Cumulative frequency of habitat use for 15 radiotagged razorback sucker in the Gunnison River, April-August 1994 and March-October 1995. The value immediately above the bars indicates the cumulative number of observations per habitat type for all 15 fish. Refer to Appendix; Table B.2. for frequency of habitat used per fish.

Spawning Surveys (Objective No. 3)

Because of the low survival of stocked fish, information was not obtained regarding movement of radiotagged fish prior to- and during the spawning period to evaluate potential spawning and to identify potential spawning areas.

Provide Recommendations for the Number and Size for Stocking Razorback Sucker (Objective No. 6)

Because only sub-adult and adult fish were stocked in this study, it was impossible to determine if smaller sizes of razorback sucker would have had better post-stocking survival. An experimental field study to be conducted between 1996 and 2000 will evaluate the relation between survival of stocked, captive-reared razorback sucker and size at release into the river. Results of this study are intended to provide additional data for the number and size of razorback sucker to stock (see section on "FUTURE STOCKING").

CONCLUSIONS

The following were conclusions from the research of this study:

1. Stocked, radiotagged razorback sucker initially moved downstream. Healthy fish appeared to move back upstream near their release sites. Stress may have had a relationship on downstream range--highly stressed fish may be more susceptible to downstream displacement.

2. Post-stocking survival was less than anticipated in both river systems. Mortality was not immediate but delayed following release for razorback sucker stocked both in the Upper Colorado and Gunnison rivers. Most radiotagged razorback sucker died within 4 months following stocking.

3. At the termination of the study, in the Upper Colorado River, 3 fish were confirmed alive, 10 were missing, 2 were confirmed dead, and 5 were presumed dead. Confirmed mortality was 10%. Actual mortality was likely as high as 85% if missing and presumed dead fish were included.

4. For fish stocked in the Gunnison River during 1994 and 1995, 3 fish were confirmed alive, 3 were missing, 2 were confirmed dead, and 17 were presumed dead. Confirmed mortality was 8%; actual mortality might have been as high as 88% if missing and presumed dead fish were included.

5. Although preferred habitats were not determined, most contacts were with fish in the main channel.

FUTURE STOCKING

A razorback sucker stocking plan for the Upper Colorado and Gunnison rivers for 1996 through 2000 that will supplement the earlier stocking plan (Burdick 1992) has been developed (Burdick et al. 1995) and accepted by the Recovery Program. The later stocking plan outlines an expanded experimental field study to determine survival and performance of stocked captive-reared razorback sucker. The study will evaluate re-introduction stocking of razorback sucker as a management strategy to develop self-sustaining populations in the Upper Colorado and Gunnison rivers. The intent is to stock all surviving captive-reared razorback sucker into the Gunnison and Upper Colorado rivers if fish meet the "Genetics Management Guidelines" (Williamson and Wydoski 1994).

The major goal of this stocking is to re-introduce razorback sucker into the Upper Colorado and Gunnison rivers and establish an adult population of 10 fish per river mile. In the Gunnison River, the target is to re-establish a population of about 600 adult razorback sucker from Austin, Colorado, downstream to the confluence with the Colorado River. In the Upper Colorado River, an initial target is to re-establish a population of about 1,200 adult razorback sucker between Rifle, Colorado, and Westwater Wash, Utah (Burdick et al. 1995). Final goals for population parameters in the different reaches will be determined from Recovery Program Management Objectives and the final recovery plan for razorback sucker (FWS 1997). The second goal is to evaluate the relation between survival of razorback sucker and size at release into the river. Other objectives of this study will be to 1) determine the dispersal of stocked fish of various sizes (4- and 8-12-inch) following release, 2) determine habitat use, 3) evaluate different gear for sampling juvenile and sub-adult razorback sucker, and 4) provide recommendations for the optimum size(s) for stocking razorback sucker into Upper Colorado River Basin rivers.

As part of this stocking effort, 316, 4-6-inch razorback sucker were stocked in the Gunnison River (RM 59.3) in October 1995 immediately downstream of Hartland Diversion Dam. None of these PIT-tagged fish have subsequently been recaptured during followup monitoring. An additional 287, 9-16-inch razorback sucker, offspring of San Juan River adult fish, were stocked 4 October 1996 in the Gunnison River (RM 57.0) at Delta. Seven of the fish stocked in 1996 were subsequently captured downstream of the stocking site one week later. The furthest razorback sucker capture was 11 river miles downstream from the stocking site.

RECOMMENDATIONS

Major recommendations (bolded print) are:

1. Stocking Sites. **Stock fish as far upstream as possible. In the Gunnison River, fish should be stocked immediately downstream of Hartland Diversion Dam (RM 60.0); the most feasible stocking location being Confluence Park boat launch (RM 57.1). In the Upper Colorado River, fish could be stocked at Rifle (RM 240.7).** Results of this and other studies conducted in the San Juan River suggest stocking as far upstream as possible due to the predominantly downstream dispersal of fish immediately following release.

2. Size, Number, and Condition to Enhance Post-stocking Survival. **Evaluate the survival and performance of different sizes of hatchery- and pond-reared razorback sucker to be released over the next 4 years in the Gunnison River to recommend the number and optimum size of razorback sucker to be stocked in riverine environments to restore populations in the Gunnison and Upper Colorado rivers.** Determining the optimum size of razorback sucker to stock should enhance post-

stocking survival. **Stock equal or near equal numbers of fish from each family lot to minimize the potential loss of genetic diversity. Document fish condition prior to release. Body condition at the time of stocking should be compared with fish that may be later recaptured.**

Five-thousand razorback sucker between 150-400 mm were stocked in Lake Mohave and researchers are presently compiling catch data to evaluate the relation between survival and size at release. Results of this study may provide insight into the optimum size to stock. However, sizes that promote optimum survival in lower basin reservoirs may not be appropriate to enhance post-stocking survival for razorback sucker released in upper basin riverine reaches.

3. Time of Year to Stock. **Stock captive-reared razorback sucker in the spring prior to runoff, if the target fish have attained adequate size. If adequate numbers of captive-reared fish are available from each family lot, stock both in the fall and spring of each year to determine the best time of year to stock.** After two years of data collection in the San Juan River, the preliminary recommendation is that stocking in the spring is best because it allows adequate time for fish to adapt to their new riverine habitat before winter. However, if the fish have not attained the target size for stocking prior to spring runoff, spring stocking may have to postponed and fish stocked the following fall.

4. Available Food Resources. **Collect food availability and density data (zooplankton densities) from potential reintroduction sites prior to stocking to determine if the habitat selected has suitable food resources for released fish.** Equally important as the temporal and spatial selection of sites to stock captive-reared razorback sucker is the consideration of available food resources at the time of release. Timing the release of hatchery-produced fish in backwater river habitats to coincide with optimum densities of food resources, i.e., large zooplankton blooms, may increase initial post-stocking survival. Domestically-produced and reared, sub-adult razorback sucker will be released in backwaters in the lower Green River to address if survival of these fish is related to the timing of zooplankton densities. These studies will be conducted by the Biological Research Division of the USGS in 1998.

5. Conditioning/Acclimation. **Determine if post-stocking survival might be enhanced if captive-reared fish are physically conditioned to flow prior to stocking. Determine if post-stocking behavioral stress can be reduced and survival increased if fish are allowed to slowly acclimate in a backwater before migrating to other riverine habitats.**

6. Stock Large Numbers of Various Sizes of PIT-tagged Razorback Sucker. **Utilize other methods beside telemetry to assess stocking survival and residence. Each stocked fish should be marked with a unique, identification code or number. Intensive monitoring should follow to determine post-stocking survival.** Stocking large numbers of fish is required to insure that adequate numbers of fish can be recaptured to

obtain enough data to perform a meaningful evaluation between survival and size at release into the river. Unfortunately, results of such releases may not be realized for several years.

7. Post-stocking Evaluation. Recapture stocked fish at 4 to 6-week intervals to assess survival, location, body condition, growth, and determine if any complications related to handling and tagging procedures occurred. Compare body condition of recaptured fish to the time of stocking. If the fish had been internally radiotagged, healing of the incision could also be evaluated.

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APPENDIX A

List of PIT-Tagged Razorback Sucker Stocked in the Upper Colorado and Gunnison rivers, Spring 1994 and Fall 1995

Table A.1. List of 20 PIT-tagged razorback sucker implanted with radiotags stocked in the Upper Colorado River, April 1994.

Frequency	Total Length (mm)	Weight (g)	PIT Tag ID	Release RM	Release Date
.010	480	1,190	7F7D16321D	220.9	940405
.030	486	1,218	7F7B103759	220.9	940405
.050	493	1,244	7F7B121F5B	211.1	940405
.070	494	1,210	7F7B08610B	211.1	940405
.090	499	1,174	7F7D13423F	228.8	940405
.110	534	1,308	7F7B1B0D04	228.8	940405
.150	477	1,036	7F7B106C11	220.9	940405
.190	532	1,416	7F7B1B594C	228.8	940405
.211	483	1,068	7F7B113037	220.9	940405
.241	487	1,498	7F7B111D67	228.8	940405
.260	489	1,252	7F7B12056D	211.1	940405
.300	517	1,256	7F7D22643A	211.1	940405
.320	504	1,140	7F7B025474	220.9	940405
.340	520	1,404	7F7B1A675B	228.8	940405
.360	532	1,394	7F7B124761	211.1	940405
.420	451	966	7F7B135351	228.8	940405
.541	474	1,080	7F7B112C53	228.8	940405
.580	526	1,428	7F7B13535C	220.9	940405
.620	528	1,422	7F7B1A4262	220.9	940405
.720	526	1,432	7F7B105C6C	211.1	940405

Table A.2. List of 25 PIT-tagged razorback sucker implanted with radiotags stocked in the Gunnison River, April 1994 and September 1995.

				Release	
Frequency	Total Length (mm)	Weight (g)	PIT Tag ID	RM	Date
.112	522	1,460	7F7D0F3452	53.6	950913
.130	472	1,128	7F7B081766	51.5	940420
.170	474	1,092	7F7D1A4D23	59.4	940406
.320	475	1,000	7F7D077771	53.6	950913
.380	463	1,132	7F7D1A2F49	51.5	940407
.390	504	1,300	7F7D1A4360	53.6	950913
.400	459	1,034	7F7D083A04	51.5	940420
.410	526	1,350	7F7D225A65	53.6	950913
.440	524	1,310	7F7D1D0865	59.4	940406
.460	464	984	7F7D225331	51.5	940406
.470	530	1,404	7F7D1E0351	59.4	940406
.480	527	1,456	7F7D027D1F	51.5	940420
.502	536	1,448	7F7D134D06	51.5	940406
.520	475	1,092	7F7D224C79	59.4	940406
.560	455	1,036	7F7D164C30	53.5	940406
.600	499	1,284	7F7D0F7A42	59.4	940406
.640	473	1,218	7F7D133A77	59.4	940406
.660	526	1,282	7F7D1D3A3A	53.5	940406
.683	462	1,066	7F7D225C16	51.5	940406
.700	512	1,430	7F7D081251	53.5	940406
.740	480	1,020	7F7D154424	53.5	940406
.760	466	1,078	7F7D135348	51.5	940406
.780	482	1,156	7F7D134555	53.5	940406
.800	526	1,476	7F7D133A31	53.5	940406
.820	467	1,142	7F7D22516A	53.5	940406

APPENDIX B

Individual Habitat Use for Radiotagged Razorback Sucker in the Upper Colorado and Gunnison rivers, 1994 and 1995

Table B.1. Individual habitat use for 12 radiotagged razorback sucker in the Upper Colorado River, April-August 1994 and March-October 1995. Refer to Figure 7.

	Radio Frequency (40.000 Mhz)	Number of Observations	HABITAT TYPE[a]									
			MC	BA	EP	SC	TS	EM	SH	PO	IP	GP
1.	.010	8	4	--	3	1	--	--	--	--	--	--
2.	.050	6	3	2	--	--	--	--	--	1	--	--
3.	.070	1	1	--	--	--	--	--	--	--	--	--
4.	.090	5	5	--	--	--	--	--	--	--	--	--
5.	.260	6	2	1	1	--	--	--	--	--	--	2
6.	.340	7	4	1	1	1	--	--	--	--	--	--
7.	.360	3	3	--	--	--	--	--	--	--	--	--
8.	.420	8	8	--	--	--	--	--	--	--	--	--
9.	.541	5	1	4	--	--	--	--	--	--	--	--
10.	.580	2	--	1	--	--	--	--	--	1	--	--
11.	.620	1	1	--	--	--	--	--	--	--	--	--
12.	.720	5	2	1	1	--	--	1	--	--	--	--
TOTALS	--	57	34	10	6	2	0	1	0	2	0	2

[a] Habitat Type: MC=main channel; BA=backwater; EP=eddy/pool; SC=side channel; TS=tributary stream; EM=embayment; SH=shoreline; PO=pool; GP=gravel pit.

Table B.2. Individual habitat use for 15 radiotagged razorback sucker in the Gunnison River, April-August 1994 and March-October 1995. Refer to Figure 8.

	Radio Frequency (40.000 Mhz)	Number of Observations	HABITAT TYPE[a]									
			MC	BA	EP	SC	TS	EM	SH	PO	IP	GP
1.	.130	3	2	--	--	1	--	--	--	--	--	--
2.	.380	4	3	1	--	--	--	--	--	--	--	--
3.	.390	5	3	1	1	--	--	--	--	--	--	--
4.	.410	5	3	2	--	--	--	--	--	--	--	--
5.	.440	9	2	5	1	1	--	--	--	--	--	--
6.	.480	4	--	3	--	--	1	--	--	--	--	--
7.	.502	12	3	--	4	1	3	1	--	--	--	--
8.	.560	2	1	--	1	--	--	--	--	--	--	--
9.	.600	6	2	2	2	--	--	--	--	--	--	--
10.	.640	3	--	2	--	--	--	--	--	--	1	--
11.	.660	12	2	4	5	--	--	1	--	--	--	--
12.	.683	13	3	6	3	1	--	--	--	--	--	--
13.	.780	13	6	2	3	1	--	--	1	--	--	--
14.	.800	9	8	--	1	--	--	--	--	--	--	--
15.	.820	9	6	--	--	1	--	--	1	1	--	--
TOTALS	--	109	44	28	21	6	4	2	2	1	1	0

[a] Habitat Type: MC=main channel; BA=backwater; EP=eddy/pool; SC=side channel; TS=tributary stream; EM=embayment; SH=shoreline; PO=pool; GP=gravel pit.

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